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Research Article

EFFECT OF MICROWAVE AND ULTRASONIC SURFACE TREATMENTS ON HEAT CONDUCTIVITY PROPERTIES OF LUFFA CYLINDRICA FIBRE REINFORCED POLYETHYLENE COMPOSITES

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ABSTRACT

Developing new natural fibre reinforced composites is the focus of many researches in recent years. Natural fibre reinforced composites are made from renewable resources and they have less environmental effect in comparison to inorganic fibre reinforced composites. Among the natural fibres, luffa cylindrica fibres are widely available throughout the world. Luffa fibres are known to have lignocellulosic fibre characteristics. In this study, luffa cylindrica fibres were treated with acetic acid by using conventional, ultrasonic and microwave methods, then thermoplastic composite structures were produced by using raw and treated luffa cylindrica fibres as reinforcement material. Finally heat conductivity properties of the luffa cylindrica fibre reinforced polyethylene composite structures were investigated.

Keywords: luffa cylindrica fibre, polyethylene, heat conductivity, composite.

1. INTRODUCTION

Natural fibres from leaves, seed or bast include coir, sisal, jute, sponge gourd (*Luffa cylindrica*), flax, ramie, abaca, kenaf, cotton, bamboo, kapok, hemp, okra, palm, wood, banana, rattan, grasses, pineapple and more. These materials are all composed of fibrils glued together with natural resinous materials in the plant tissue. These lignocellulosic fibres are biodegradable, eco-friendly, low cost and have high strength to density ratios, all properties that are attractive for automotive and other composite applications. Luffa cylindrica fibre is obtained from the fruit of the *Luffa cylindrica* lignocellulosic plant. It is a member of a generic group of eight species known as 'vegetable sponges', which are herbaceous trailing perennials producing fruits with a fibrous vascular system. This is quite common in the mid-south of America, and is cultivated in Africa, Asia and Australia for the cylindrical fruits. Its size varies in relation to the areas in which it is grown, ranging from 15 cm to 1 m or more. In Turkey, Luffa cylindrica grows well in the areas of Mediterranean climate, with creeping stems reaching 9 m. The diameter of the basic fibre is 20–50 μm. The struts of this natural sponge are characterized by a microcellular architecture with continuous hollow micro-channels (macro-pores with diameter of 10–20 μm) which form vascular bundles. They consist of a cellulosic polymer with various non-cellulosic impurities [1-5].

Surface treatment processes are applied to the luffa cylindrica fibres to improve the adhesion between the luffa fibre and the matrix of the composite. Generally alkali and acidic surface treatment processes are applied to luffa cylindrical fibres to clean and roughen the surface of the fibres by using conventional and ultrasonic methods [6-8].

2. MATERIAL AND METHOD

2.1 Material

Luffa cylindrica fibres were used for the reinforcement of the polyethylene thermoplastic composites. Luffa cylindrica fibres were obtained from the Mediterranean zone of the Turkey. Luffa cylindrica fibres used in this study are shown in Figure 1.

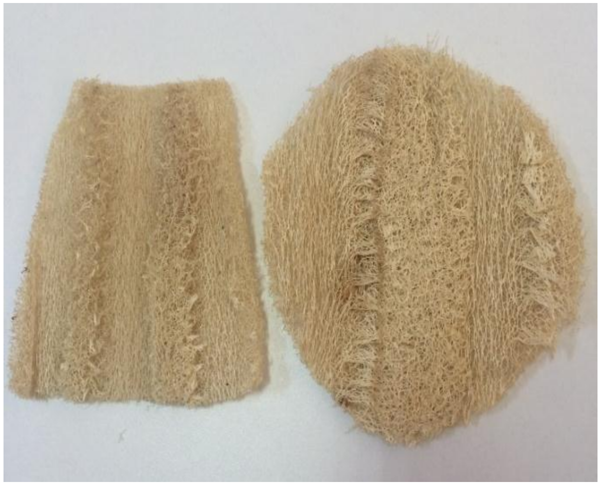

Fig. 1: Luffa cylindrica fibres used as reinforcement in composites

2.2 Surface Treatment of Luffa Cylindrica Fibres

Luffa cylindrica fibres were treated with acetic acid by using conventional, ultrasonic and microwave energy methods. Conventional treatment process was performed at room temperature for 30 minutes. Ultrasonic treatment was applied to the luffa fibres for 20 minutes at room temperature by using B2200B E4 (220V, 205W and 20kHz frequency) ultrasonic bath. Microwave treatment method was applied to luffa fibres for 5 minutes, at ML (Medium-Low) level, at the frequency of 2.45 GHz by using Kenwood MW 440 microwave oven.

2.3 Production of the Composites

Using acetic acid treated and untreated luffa cylindrica fibres as reinforcement material and polyethylene granules as matrix; polyethylene thermoplastic composite structures were manufactured. Thermoplastic composite structures were manufactured by using hot press compression machine, which is shown in Figure 2. Temperature of the hot press compression was set to 200 °C, and production process was completed in 60 minutes for each composite structures. Aluminium moulds were used for the production of the thermoplastic composite structures. Pressed composite structures were cooled at room temperature. After cooling, composite structures were cut circular at the diameter of 26 mm for the heat conductivity analyses.

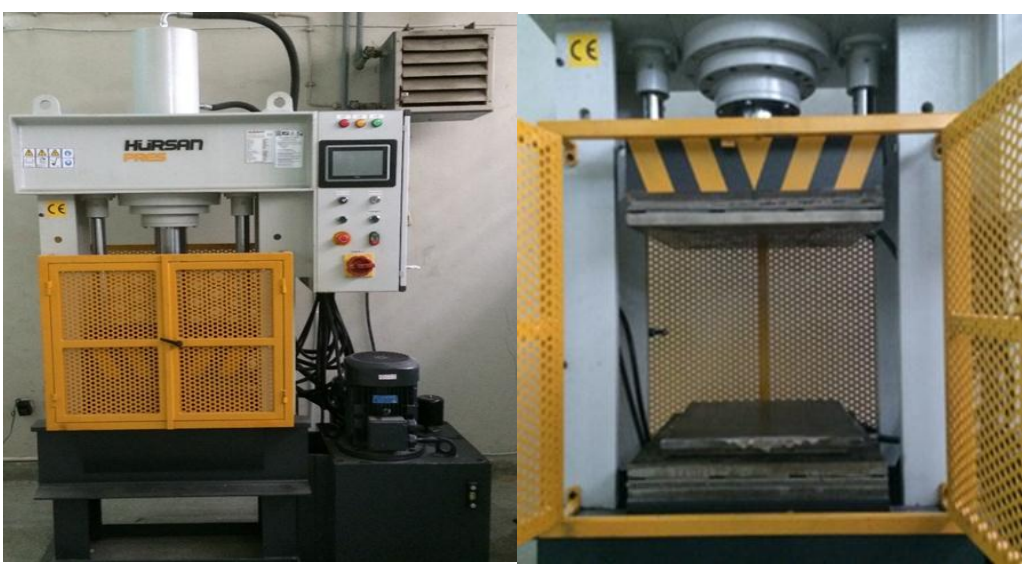

Fig. 2: Hot press compression machine

2.4 Heat Conductivity Testing of the Composites

Heat conductivity analyses of the produced composites were performed by using P.A. HILTON LTD. H940 testing instrument which is shown in Figure 3. Test samples were prepared by cutting the composites circular at the diameter of 26 mm. Photos of the heat conductivity test samples are given in Figure 4. After preparation of the heat conductivity test samples, they were placed into the instrument and temperature readings were measured in every 10 minutes. Heat conductivity coefficient (k) of the composites was calculated according to the equation 1 shown below.

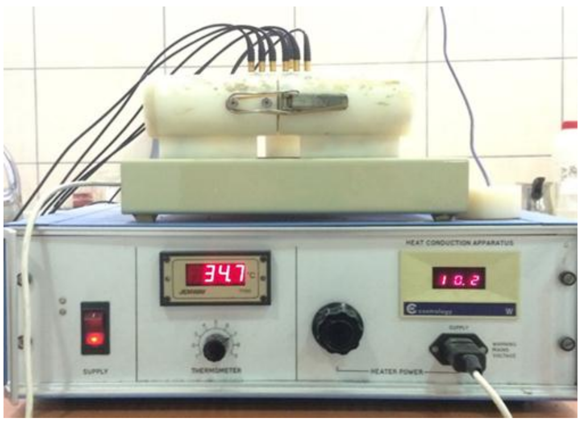

Fig. 3: Heat conductivity testing instrument

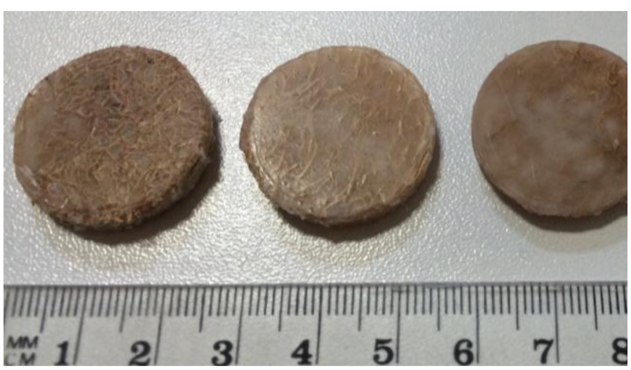

Fig. 4: Heat conductivity test samples of luffa cylindrica fibre reinforced composites

$$\boldsymbol{k} = \frac{Q.dx}{A.\Delta t}$$

Where;

Q is the value of the heat flow, dx is the thickness of the composite, A is the surface area of the composite, ΔT is the difference of the heat, k is the heat conductivity coefficient.

3. RESULTS

Heat conductivity test results of the produced luffa cylindrica fibre reinforced polyethylene thermoplastic composites are given in Table 1.

Table 1: Heat conductivity test results of the luffa cylindrical fiber reinforced polyethylene composites

Composite Samples	k (W/mC°)
Sample 1 (Untreated)	1.777
Sample 2 (Treated by conventional method)	1.681
Sample 3 (Treated by ultrasonic energy method)	1.657
Sample 4 (Treated by microwave method)	1.643

According to the Table 1, it is seen that better heat conductivity results were obtained from acetic acid treated luffa cylindrica fibre reinforced composites. Surface treatment processes were improved the heat conductivity properties of the composites. It is seen from the results that microwave treatment has better effect on the heat conductivity properties of the composites than ultrasonic and conventional processes due to the increased effect of microwave energy.

4. CONCLUSION

Surface treatment processes of the luffa cylindrica fibres with acetic acid improved the heat conductivity properties of the composites. Cleaning and roughen the surface of the luffa cylindrica fibres improved the heat conductivity properties of the luffa cylindrica fibre reinforced polyethylene thermoplastic composites. Microwave energy process has better effect on the heat conductivity properties of the luffa cylindrica fibre reinforced polyethylene composites than conventional and ultrasonic processes.

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